BELLCOMM, INC.
955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D. C. 20024

B70 03047

SUBJECT: Analysis of Air-Ground Voice Contacts During the Apollo 12 Launch Phase - Case 900

DATE: March 16, 1970

FROM: L. A. Ferrara

ABSTRACT

A study has been made of the air/ground voice communications between the Apollo 12 spacecraft and the ground network during the launch phase to determine the effects on communications of (1) the lightning strike on the spacecraft shortly after liftoff and (2) the absence of the Grand Bahama tracking station on the communications coverage. The analysis indicates that the lightning caused the MILA S-Band system to lose communications for about 30 seconds. In addition to loss of receiver output, the uplink voice and probably command capability was lost during this period due to reacquisition procedures. VHF uplink and downlink voice communications were only slightly affected by the lightning. The USB downlink signal was also lost during the period between two and three minutes when spacecraft staging occurred. This was the period of time when the Grand Bahama station would have had prime contact with the spacecraft. The MILA VHF communications during this period were continuous, however. An FM voice receiver in the USB downlink similar to the one recommended for telemetry should ameliorate the voice loss experienced during the S-IC/S-II staging.

The analysis also revealed a consistent pattern of clipping of the initial syllables of the uplink voice from the MILA and Bermuda stations. This clipping is believed due to an unexplained delay in the reaction time of the modulator keying units on both the VHF and S-Band transmitters and warrants further investigation.

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MEMORANDUM FOR FILE

1.0 INTRODUCTION

An analysis has been made of voice communications to and from the spacecraft during the launch phase of the Apollo 12 mission. Voice recordings of the Unified S-Band (USB) and VHF Air-Ground loops from the MILA and Bermuda MSFN ground stations were compared with the recordings and transcript (Reference 1) of the voice transmissions originating at and received at the Mission Control Center in Houston. The purpose of the analysis is to determine the effects of the lightning discharge, which occurred shortly after liftoff, on the continuity of communications, as well as the effect of the absence of the Grand Bahama Apollo MSFN station on the communications coverage.

A voice contact chart (Figure 1) has been prepared to summarize the voice transmissions to and from the spacecraft as observed from the recordings made at the three locations (MCC, MILA, BDA). Observations concerning the quality and continuity of the voice communications at each location are discussed in Section 2.0, along with an evaluation of any observed anomalies. A summary of the findings is presented in Section 3.0. Appendix A discusses the observed phenomena of clipped uplink voice in further detail and offers a possible explanation for the anomaly.

The content of this memorandum was reviewed with GSFC personnel on March 2, 1970, and they are investigating the reported phenomena.

2.0 OBSERVATIONS

The observations in this section are based on the tape recordings made at the sites, copies of which were obtained from MSC and GSFC. Although certain of the requested tapes were not available to us, e.g., Bermuda USB and VHF verification tapes, MILA VHF verification and A/G-1 loop, so that complete analysis was not possible, those that were available permitted interpretation of the major phenomena. The times listed are Ground Elapsed Time (GET) from liftoff in minutes and seconds. MILA is used throughout this report to denote the USB MSFN station at KSC. The letters in parentheses which are noted in the following paragraphs are keyed (e.g., Key A) to the corresponding circled letters on Figure 1.

2.1 MSFN Station at Cape Kennedy (MILA)

2.1.1 USB Up-voice

Up-voice was good quality as heard on the USB CSM A/G loop recording from before liftoff through handover of the uplink to Bermuda at $6^m:00^s$ (GET). One uplink transmission at T+$2^m:06^s$ ("Apollo 12, Houston. Go for staging.") was at a very low level and masked by static (Key B). One transmission at T+$2^m:50^s$ ("Roger, we copy, Pete. You're looking good.") was missing (Key C). The first syllables or portions of uplink phrases were noted to be missing as if clipped by the slow reaction time of a keying device in almost all transmissions after T+1 minute. This phenomenon is similar to the one observed during the launch phase of the Apollo 10 mission (Reference 2).

2.1.2 USB Down-voice

The Apollo 12 downlink voice contact as recorded at MILA on the USB A/G loop to the CSM extended from before liftoff to the end of the tape at T+$\sim 7^m:30^s$. Static built up on the recording at T+36^s at the time of the lightning discharge and persisted for about 25 seconds, causing the T+$00^m:44^s$ transmission by the spacecraft CDR ("Roger, we had a whole bunch of buses drop out.") to be garbled (Key A). Downlink transmissions were also missing from the onset of static at T+$2^m:04^s$, "EDS AUTO," (Key D) (which was faintly heard) until T+$2^m:53^s$ when the CDR transmitted, "Okay, now we'll straighten out our problems...." It was also noted that the voice levels on the recording dropped noticeably during the period from T+$4^m:44^s$ to T+$\sim 5^m:30^s$ (Key E) during which time short segments of Operational Intercomm System (OIS) conversations could be heard in the background. Only one call on Channel 111 could be clearly identified.

2.1.3 USB Verification Receiver

The tape of the MILA USB uplink voice as recorded at the output of the MILA verification receiver indicated there was no uplink from the time of the lightning hit (Key F) (T+36^s) until the Cap Comm, "Roger," at $1^m:08^s$. The tape

also shows the T+2^{m}:50^{s} Cap Comm transmission (Key C-1), "Roger, we copy, Pete. You're looking good," and the 3^{m}:19^{s}, "Amen," (Key G) to be missing. The tape verifies that all uplink messages transmitted after the first minute had the initial syllables clipped.

2.1.4 VHF Up-voice

The VHF uplink voice at MILA as heard on the VHF A/G loop recording was of good quality and was present on the tape from before liftoff through 6^{m}:00^{s} when the uplink was handed over to the Bermuda station. There was no clipping of the initial syllables as was observed on the USB uplink tapes.

2.1.5 VHF Down-voice

Spacecraft voice was clearly heard from before liftoff through the end of the tape (∿T+8^{m}:50^{s}). Some background noise appeared on the tape from T+1^{m}:00^{s} to T+1^{m}:45^{s}, but did not affect the intelligibility of the voice signals (Key H).

2.1.6 VHF Verification Receiver

Uplink voice on VHF was clearly heard from before liftoff to ∿T+20 seconds when the recording ceased. Therefore, no verification could be made as to the presence or absence of clipping on the VHF uplink transmissions.

2.1.7 MILA Net 1 Goss Conference

2.1.7.1 Up-voice

Up-voice was clearly heard on Goss Conference starting with the T+00^{m}:20^{s} Cap Comm transmission, "Roger, Pete," which was the first MCC up-voice following the LCC 39 originated, "Clear the tower." There was no evidence of clipping of the initial syllables of the uplink such as those observed in the USB A/G loop recording. "Clear the tower," was the last uplink from LCC 39 and was heard in the spacecraft, but not at MILA or MCC on Net 1 although it was present on the MILA USB recording. This is in accordance with the pre-launch air ground configuration rules as stated in Reference 7.

2.1.7.2 Down-voice

Downlink spacecraft voice was loud and clear from four minutes prior to liftoff to the end of the tape at $T+9^m:25^s$ with the exception of the $T+00^m:44^s$ transmission from the CDR, "Roger, we had a whole bunch of buses drop out," and "EDS AUTO," at $T+2^m:04^s$ which were low level and masked by static (Key A-1).

2.1.8 Evaluation of Communications Performance at MILA

The overall performance of the VHF uplink and downlink voice communications system based on the MILA recordings for the period examined was good and noticeably better than the USB system for this time period.

The lack of a downlink squelch unit in the USB receiver circuit could have aggravated the receiver noise problem during the two dropouts noted at $T+00^m:35^s$ to $1^m:00^s$ and $T+2^m:08^s$ to $2^m:48^s$. There is cause to believe that the compression amplifiers in the receive circuit were driven by noise into limiting, thereby reducing the gain during this period. The VOGAA squelch unit had been removed for this mission, and no alternate squelch unit was installed.

The short burst of downlink USB voice during the dropout caused by lightning was believed to have been obtained by the frequency sweeping of the receiver during the reacquisition sequence. A special FM receiver had been recommended to be used with the USB system to receive telemetry when phase lock is lost (References 8 and 9). The similar use of an FM receiver for the USB voice link would ameliorate the voice loss which coincided with S-IC/S-II staging and other disturbances.

It is to be noted that command capability was probably also lost during the $00^m:36^s$ to $1^m:00^s$ period when modulation was off during the reacquisition period.

The drop in voice level noted on the recordings during the $T+4^m:42^s$ to $T+5^m:30^s$ period could have been caused by AGC action in the system ahead of the recorder bridge. Compression amplifiers adjust gain according to total inband energy accepted at the input. High level crosstalk mixed with the signal could cause amplifier limiting and a net reduction in gain.

The reason for the short segments of OIS conversations heard on the tape is not clearly understood. The Astro Comm

circuit from LCC 39 is the major OIS related path to the Comm Tech Console. This circuit, however, was inhibited at Tower Clear (T+12 seconds) to prevent the Cape voice traffic from being transmitted over the air/ground transmitter to the spacecraft.

Review of the KSC Apollo Astro Communications drawing (Reference 5) does not reveal how the VHF or USB uplink voice can be removed from the circuit without also removing the downlink voice. The VHF and USB air/ground recordings at MILA, however, do have VHF downlink voice after the handover to the Bermuda station at $T+6^m:00^s$. It is understood that the VHF A/G recording is made from the House Circuit leg of the VHF-1 4Wire-4Way Bridge (4W-4W) and the USB A/G recording, from the CSM 4W-4W Bridge. It is assumed that an inhibit plug (or switch) in the uplink circuits is not shown on the drawing.

The background buzz heard on the VHF A/G recording from $T+1^m:00^s$ to $T+1^m:45^s$ is believed due to different squelch settings on the VHF receivers. Due to interference from an adajacent telemetry link on the booster, a heavily squelched VHF receiver is to be used for the first minute after liftoff. At T+1 minute, a second receiver is switched into the circuit with a different squelch setting. The buzz observed is believed to be from this second receiver.

Analysis of the VHF and USB signal strength records for this period may provide more visibility into the USB dropouts and weak signals observed. It should be particularly helpful to compare the spacecraft VHF voice and booster VHF telemetry signals strengths.

2.2 MSFN Station at Bermuda (BDA)

2.2.1 USB Up-voice

Up-voice was present on the BDA USB A/G tape from $T+4^m:03^s$ until the end of the tape at $10^m:11^s$. The voice quality was good, undistorted and of even level. The recording point was before the switch closure on the exciter control panel of the BDA USB transmitter and represented the primary A/G feed from MCC, which was not uplinked to the spacecraft until the prescribed handover time of $T+6^m:00^s$ at which time the transmitter carrier was turned on. As in the case of the MILA USB uplink, the initial syllables were clipped from almost all the Cap Comm transmissions appearing on the tape.

2.2.2 USB Down-voice

First down-voice appeared on the tape at $3^m:46^s$ about 15 seconds after BDA AOS. Voice quality and level was good until the end of the tape at $10^m:12^s$. No background noise, signal distortion or missing words or transmissions were evident.

2.2.3 USB Verification Receiver

The quality of the USB voice transmitted to the spacecraft could not be determined because there was no signal on the verification receiver tape. GSFC personnel confirmed the absence of signal on the original Bermuda recording.

2.2.4 VHF Up-voice

Up-voice first appeared on the BDA VHF A/G tape at $4^m:03^s$ with a high level echo and some clipping of the initial syllables or phrases. The uplink voice clipping was only evident on the first two Cap Comm transmissions from MCC. All the uplink transmissions until the end of the tape at $8^m:40^s$ contained bothersome echoes, but were generally undistorted and readable.

2.2.5 VHF Down-voice

Heavy distortion caused by multiple echoes was present on the tape from the first downlink transmission at $T+3^m:46^s$ (Key I). The down-voice was barely readable. At $T+6^m:13^s$, the first spacecraft transmission after the uplink handover from MILA was less distorted, but still contained a strong echo which was at about the same level as the true signal. The poor quality downlink voice with echoes and some distortion continued until the end of the tape at $T+8^m:45^s$.

2.2.6 Goss Conference Uplink Voice

The Goss Conference primary air/ground net as recorded at Bermuda contained a good quality and level uplink voice. The tape segment covered the period from liftoff through the Cap Comm transmission at $T+14^m:44^s$, and there was no evidence of clipping of the initial syllables or phrases.

2.2.7 Goss Conference Down-voice

The down-voice at BDA was clear and appeared identical to the voice as recorded at MCC from liftoff to the first USB down-voice recorded at Bermuda at $T+3^m:46^s$ (Key J). At this time, a very hollow, barrel effect to the downlink voice appeared on the recording. The down-voice was readable, but distorted. This barrel effect remained until the transfer key click signifying the handover of the uplink to Bermuda at $T+6^m:00^s$, following which the down-voice became clear on the recording. The Bermuda techician verified to Houston Comm Tech on Net 2 (called Net 3 on the BDA recordings) that good quality USB voice was being received at BDA and was being remoted to MCC. At $T+10^m:52^s$ following a short buzz on the recording, the down-voice again appeared with a heavy echo and became somewhat distorted. The echoes and distortion remained until the end of the tape at $T+14^m:44^s$ (Key J-1).

2.2.8 Evaluation

Based on the poor quality due to the echoes and distortion of the VHF voice as recorded on the A/G loop recordings, it would appear that Mission Control would have had considerable difficulty in communicating with the Apollo 12 crew had it been necessary to use the VHF equipment as the prime voice link during the Bermuda contact.

It is recognized that the recordings used in this analysis were made from a multiplex recording and that problems could exist in the initial recordings and/or subsequent data reduction which may have caused some of the distortion or echoes inasmuch as some of the recordings furnished for this analysis have evidence of crosstalk of two different voice nets on one channel. On the other hand, the timing of the echoes and distortion as they appear on the primary Air Ground Net (Goss Conference) on the Bermuda tape leads one to suspect a configuration problem at the Bermuda station. For example, the onset of the barrel effect on Goss Conference matches the first USB and VHF down-voice recorded. The sudden clearing of the downlink voice on the same recording coincides with the handover to Bermuda station.

The almost identical clipping of uplink Cap Comm voice on the MILA and Bermuda recordings of the USB CSM A/G

voice loop and the absence of this up-voice clipping on the VHF and Goss Conference recordings at these two stations is a problem which also merits further investigation.

2.3 Mission Control Center-Houston

2.3.1 MCC A/G-2 Up-voice (Configured to Air-Ground 1 Long Lines from MILA)

Uplink voice on this tape starts just before liftoff and ends at $T+1^m:08^s$ with the Cap Comm transmission, "Roger." Voice was loud and clear; no clipping of initial syllables was evident. Uplink voice from KSC heard on this tape prior to the "Tower Clear" cutover is possible through the monitor bridge at MILA. This conclusively states the Cap Comm did not start talking before actuating the push-to-talk button.

2.3.2 MCC A/G-2 Down-voice (A/G-1 Long Lines from MILA)

Down-voice on the tape starts at liftoff and ends after the $T+8^m:36^s$ transmission by the CDR, "Okay. You want the LMP to turn off the G&N...." This coincides with the end of the VHF A/G loop tape at MILA. There are two segments where down-voice is missing on the tape; one is right after the $T+2^m:04^s$ CDR transmission, "EDS AUTO," (Key K) when static is building up on the tape and transfer key clicks can be heard until the $T+2^m:53^s$ transmission from CDR, "Okay. Now we'll straighten out our problems...." Two downlink transmissions were lost during this interval ($2^m:04^s$ to $2^m:53^s$). When the down-voice resumed, it appeared to be crisper and the MILA USB receiver may have been feeding Air-Ground 1 Long Lines at this time.

The tape became quiet for about 80 seconds following the $T+6^m:13^s$ transmission by the CDR, "Okay. Here comes the Gimbal motors," and voice signals resume at $T+7^m:43^s$ (which is also the end of the MILA CSM USB A/G loop tape) (Key L). Good quality down-voice continues until the end of the tape at $T+8^m:42^s$. It is believed this last segment is MILA VHF down-voice. "Liftoff" and "Clear the tower" callouts from LCC 39 are heard on the tape and on the MILA USB and VHF A/G tapes.

2.3.3 MCC Goss Conference (Net 1) Up-voice

Cap Comm voice with full Quindar tones at the beginning and end of each transmission appear in the MCC tape from $00^m:20^s$ to the end of the tape, $T+10^m:15^s$. Voice level and quality is good and no clipping of initial syllables was evident.

2.3.4 MCC Goss Conference Down-voice

With the exception of the weak transmission at $T+00^m:44^s$ (Key A-3), which was masked by static as a result of the lightning hit on the vehicle, and the weak $T+2^m:05^s$ "EDS AUTO" callout during a second static burst (Key D-3), all down-voice was of good quality. Comparison with the Technical Transcript (Reference 1) indicates that the $T+00^m:44^s$ callout was garbled and the $T+2^m:05^s$ "EDS AUTO" was probably too weak to be noticed. Otherwise, there is complete agreement between the tape and the transcript for the period analyzed. "Liftoff" and "Clear the tower" from LCC39 are not heard on Net 1 at MCC. This is also in accordance with procedures.

2.3.5 Evaluation

It appears that the MILA USB receiver was feeding Goss Conference MCC (A/G-1) from liftoff through $T+\sim 2^m:05^s$ while the MILA VHF receiver was connected to A/G-2 at MCC. At about $T+2^m:10^s$ after the MILA Comm Tech realized he had bad USB down-voice, the downlink signals to Houston appear to have been transposed possibly because of the USB dropout at MILA. This resulted, however, in putting the best down-voice on the Goss Conference primary A/G net. VHF down-voice should have also been patched to Net 1 during the outage ($T+00^m:36^s$ to $T+1^m:00^s$) occasioned by the lightning hit. Complete assessment of this anomaly requires the MILA A/G-1 Long Lines loop recording which was not available (see Figure 2). It is assumed, however, that key personnel at MCC had both down-link voice sources available to them and between the two (A/G-1 and A/G-2), had virtually continuous and satisfactory downlink communications as long as MILA was sending both VHF and USB receiver outputs to MCC. Simultaneous feeds over different circuits to MCC and to MILA could, however, cause distortion due to out-of-phase signals. This may also be the cause of the reported echoes from Bermuda. Figure 3 is a sketch of the multiple voice paths.

The MCC console recordings would have to be analyzed to make an assessment of the effects of the echoes and distortion noted on the Bermuda circuits.

3.0 SUMMARY

Lightning Effects

1. The lightning strike during the Apollo 12 launch ($T+36^{s}$) interrupted USB communications with MILA for about 25 seconds, but affected VHF voice communications only to a minor degree.

2. The USB downlink was lost at MILA due to the lightning strike. The uplink was removed according to the USB verification receiver, at the same time apparently removing the downlink from Net 1. Apparent loss of uplink and downlink may not be related. According to the site drawing (Reference 5), the downlink noise could have been removed from the circuit without also disabling the uplink. Command capability was probably lost during this uplink outage during the reacquisition period.

Absence of Grand Bahama Station

3. The absence of the Grand Bahama MSFN station did not degrade VHF communications coverage for this mission (72° launch azimuth). There was some evidence of weak and missing USB down-voice between two and three minutes, the time period which used to be covered by the GBM site. This is the period when booster plume, staging and bad look angles have caused previous problems with MILA reception. References 2 and 3 indicate an overlap in coverage and positive communication margins between MILA and Bermuda even at the highest launch azimuth (108°). Furthermore, it is believed these references contain conservative calculations because they indicate AOS Bermuda should occur about $T+4^{m}:20^{s}$ from liftoff in the worst case (108° Launch Az.) and about $T+4^{m}:00^{s}$ at 72° Launch Az. Bermuda AOS for this mission was $T+3^{m}:20^{s}$ GET.

Clipping

4. The uplink portion of the air/ground station tapes for MILA and Bermuda indicating what was presented to the transmitter modulators shows the USB uplink to be clipped on the initial syllables.

5. The VHF Air/Ground loop tapes for the two stations do not indicate clipping on the uplink.

6. Comparisons of the clipped uplink messages as heard on the USB Air/Ground tapes from MILA and Bermuda with the transcript of the DSE voice from the spacecraft (Reference 6) indicates that most of the clipped words did not get through to the spacecraft.

7. In at least one instance, (2^m:50^s) where there was no USB uplink as verified on the MILA USB verification receiver, the VHF uplink was apparently clipped because the initial "Roger..." was missing from the spacecraft tape transcript.

8. Analysis of the clipped initial phrases on the uplink indicates a keying problem at MILA and probably Bermuda and possible other MSFN stations. Further investigation is warranted (see Appendix A).

Bermuda Distortion

9. The Bermuda VHF A/G loop distortion on the downlink and echoes on the downlink and uplink may be a recording problem at Bermuda and/or a circuit termination problem.

10. The "barrel effect" and echo observed on the Bermuda Goss Conference tape down-voice could similarly be a circuit termination and/or recording problem. In either case, further investigation is considered warranted.

MILA Operation

11. It may be helpful to review the operational procedures for the MILA station relevant to USB system performance during staging.

12. The use of an FM receiver for receiving voice over the USB link when phase lock is lost, as at staging, should be considered.

2034-LAF-drc

L. A. Ferrara

Attachment
Figures 1 thru 3
Appendix A

REFERENCES

1. Apollo 12 Technical Air-to-Ground Voice Transcription, NASA MSC, Houston, Texas, November, 1969.

2. Ferrara, L. A., "Voice Communication Analysis During the Apollo 10 Launch," Memorandum for File, October 8, 1969.

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4. Hill, J. D., Selden, R. L., "Unified S-Band Communications Margins During the Launch Phase of a Saturn V Apollo Mission," Memorandum for File, March 16, 1965.

5. "Apollo Astro Communications, MILA USB Site," NASA KSC Drawing No. FEC/SOAS-10001, Revision D, September 17, 1969.

6. Apollo 12 Onboard Voice Transcription (U), Confidential, MSC, Houston, Texas, January, 1970.

7. NASA Long Lines Communications Guide, AS-507, Air-Ground Supplement, Manned Spacecraft Center, Houston, Texas, October 14, 1969.

8. Quarterly Progress Report, Manned Spaceflight Network Study Program, Space Communications Group, Johns Hopkins University, Applied Physics Laboratory Report CSC-0-160, December, 1969.

9. Minutes of the Apollo 12 Communications Systems Review, MSC Document EE7-9/69-47, September 20, 1969.

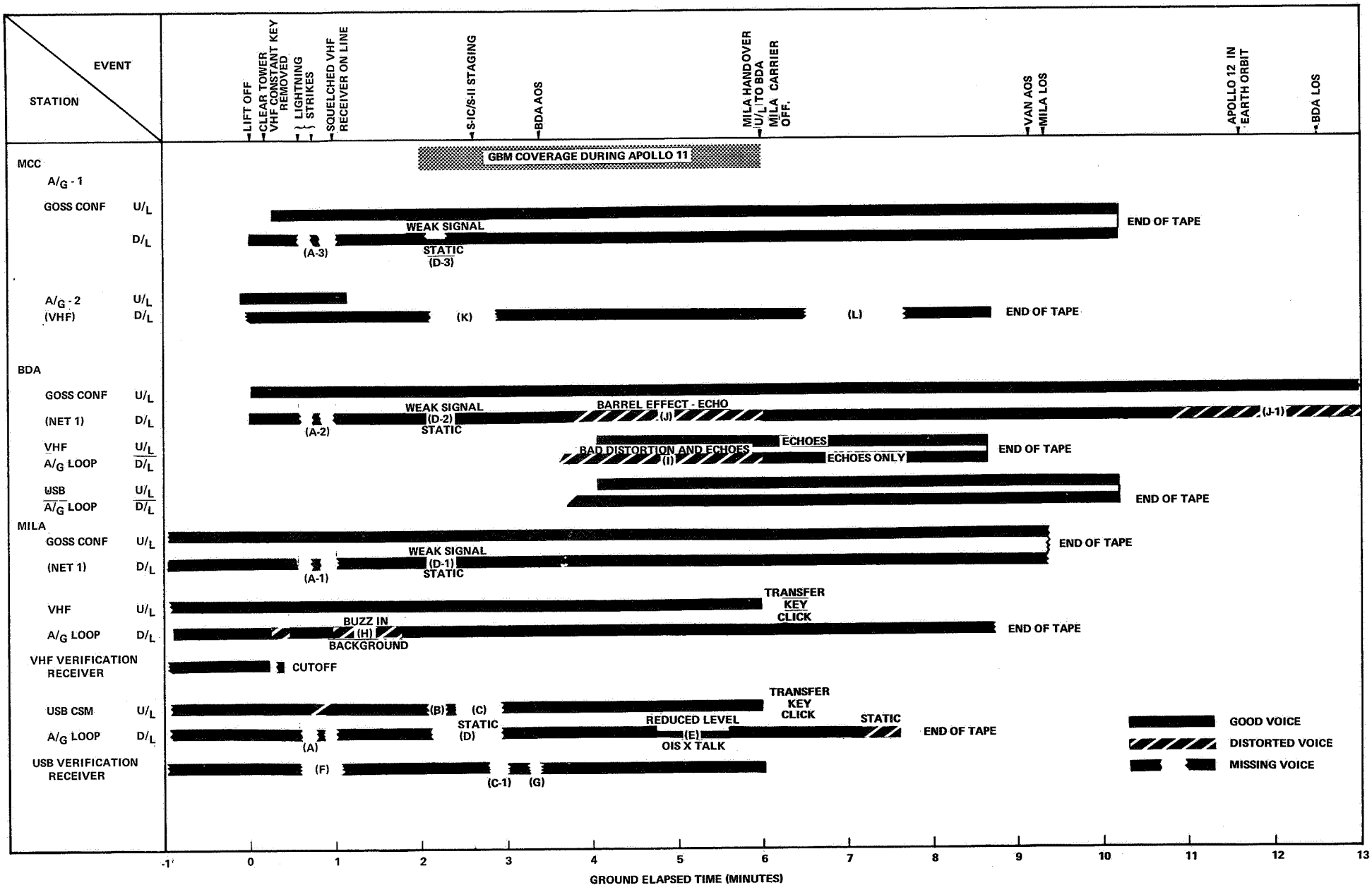


FIGURE 1. APOLLO 12 LAUNCH PHASE VOICE CONTACT ANALYSIS

PRELAUNCH AIR/GROUND CONFIGURATION

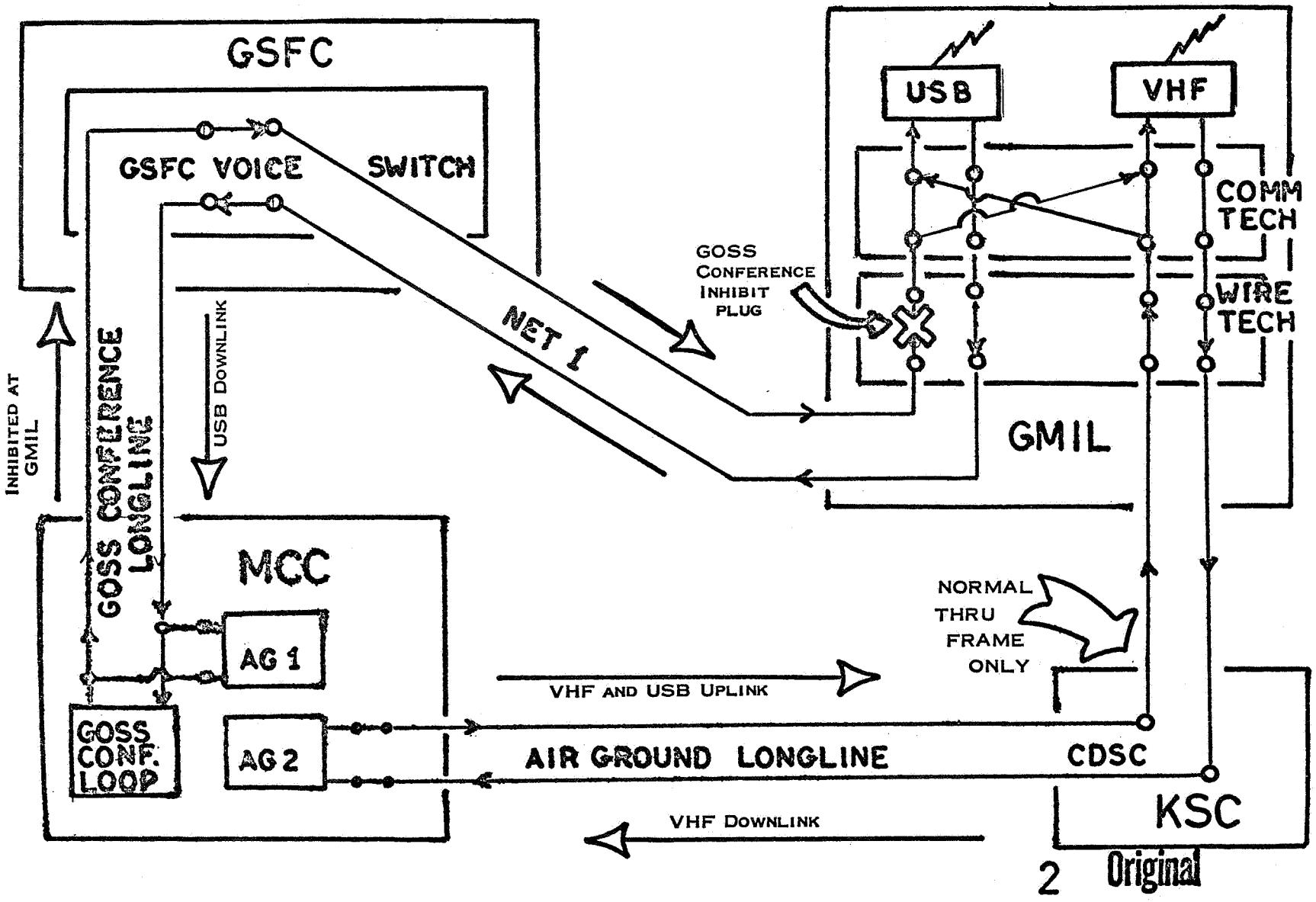


FIGURE 2

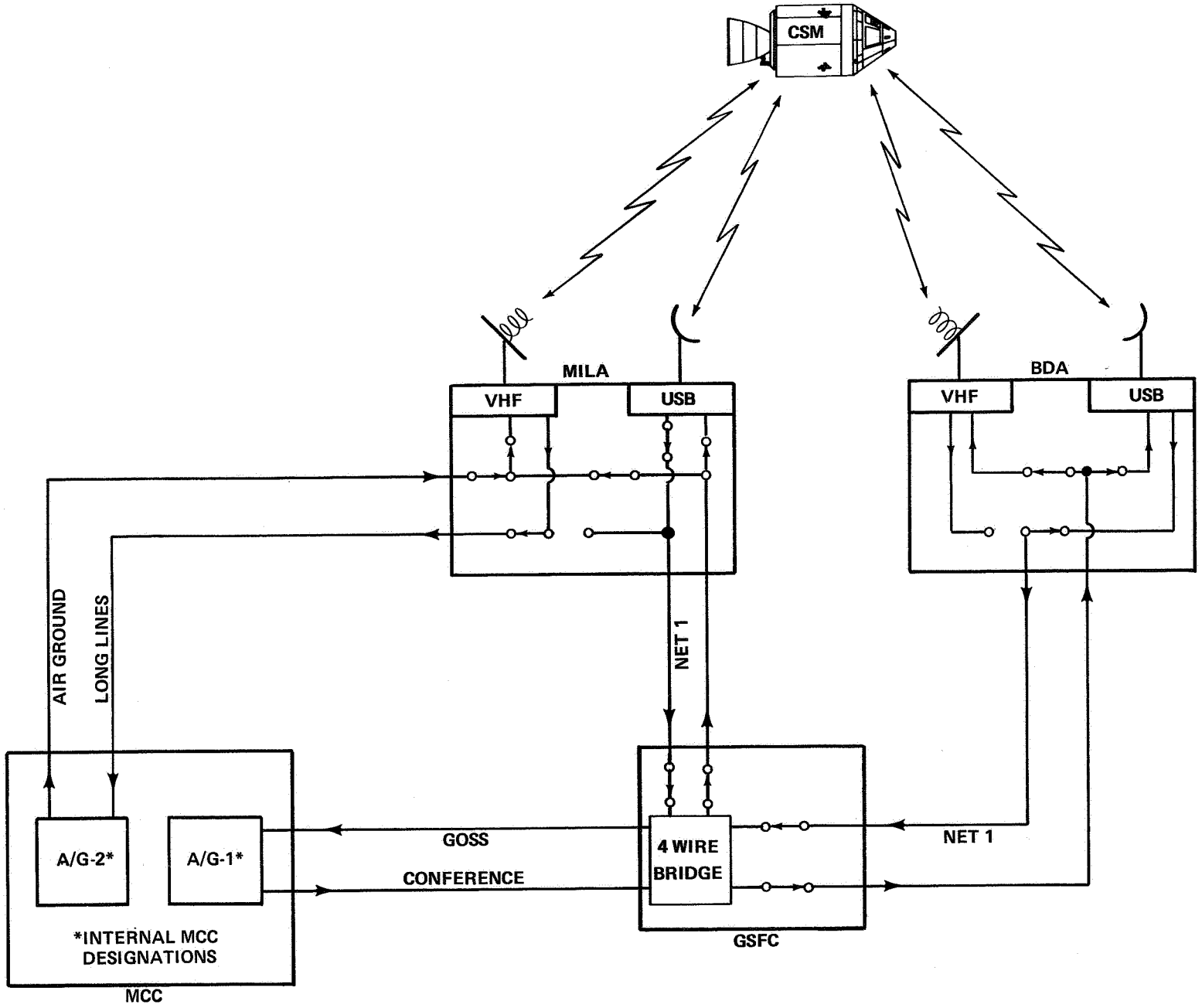


FIGURE 3 - FUNCTIONAL SOURCES OF MULTIPLE VOICE PATHS

APPENDIX A

CLIPPING OF THE UPLINK VOICE TRANSMISSIONS DURING THE APOLLO 12 LAUNCH PHASE

Analysis of the voice transmissions to and from the Apollo 12 spacecraft during launch indicates a pattern of clipping of the uplink transmissions on both VHF and USB from the MILA and Bermuda MSFN stations. The loss of the initial syllables and phrases is similar to the anomalies experienced on the uplink voice from MILA during the launch of Apollo 10 (Reference 2).

Voice recordings from the MILA USB air/ground loop and the associated USB verification receiver indicate the first part of the voice signal is lost at the site prior to transmission. In one instance, the first 150 milliseconds were missing (Figures A-1 through A-4). Analysis was not performed to determine if the amount clipped in each case is constant or variable.

Referring to the voice communications configuration drawing for the MILA USB site (Reference 5), the most likely cause appears to be the reaction time of the keying relay Q1 or its associated circuitry. At the MILA site, this relay is located just before the jack field and the CSM 4W-4W bridge, the house circuit legs of which are understood to be the connection point for the CSM USB A/G voice recordings which were analyzed. The keying relay Q1 was actuated by either the VOGAA keying sensor or the Quindar keying sensor [Q] on the drawing.

The companion relay, Q2, is located after the recording bridge leg for the VHF signal (Figure A-5). Thus, a delay in actuating the VHF and USB keying relays because of Quindar keying sensor reaction time or sluggish operation of the keying relays could cause clipping on the initial phrases of both the VHF and USB uplink transmissions. Due to the position of the recording points in the circuit, only clipping on the USB uplink was observed, but it is suspected both uplink transmissions were clipped to some extent.

APPENDIX A

Inasmuch as only the USB verification receiver recording was available from MILA (the VHF verification receiver recording was too short -- T+20 seconds -- to be conclusive) and no off-the-air uplink transmission recordings were made at Bermuda; only one transmission is available to substantiate this explanation. During the period when the MILA USB uplink was disconnected ($\sim 2^m:08^s$ to $2^m:54^s$), there was one uplink transmission by VHF ($2^m:50^s$ -- "Roger, we copy, Pete..."). The transcript of the DSE voice shows that this VHF transmission was also clipped (the "Roger" was missing). As in the Apollo 10 mission, there was no uplink voice clipping observed during the first minute. This is believed due to the different reaction time of the Quindar access (receiver) on the direct air/ground 1 circuit. The uplink circuit from MCC is transferred from A/G-1 to Goss Conference (Net 1) at one minute.

The Bermuda voice communications configuration for the launch phase was similar to MILA, i.e., transmit USB and VHF simultaneously. Likewise, the Bermuda recordings show clipping on the USB uplink; no clipping on the VHF uplink. Although no Bermuda verification receiver (VHF or USB) recordings were made, the transcript of the spacecraft on-board tape shows the ground transmissions clipped on the initial syllables or short words for most of the uplink transmissions from the Bermuda site as well as from MILA.

TIME DURATION OF CLIPPING

Since the VOGAA keying sensor was presumed to be inhibited at MILA and not in the configuration at Bermuda, the Quindar tone transmitter and receiver combination was examined. The QT-30, QR-30 model used in the MSFN transmits a 280 millisecond tone at 2525 Hz to turn on the remote transmitter as soon as the push-to-talk key is actuated at MCC. At the end of the transmission when the push-to-talk button is released, a second 280 millisecond tone at 2475 Hz is generated which turns off the remote transmitter. These tones can be seen in Figure A-1, which is a time frequency spectrogram of the $1^m:57^s$ (GET) Cap Comm transmission, "Mark one Charlie," as recorded at MCC. Figure A-2 shows the same transmission as recorded from the Goss Conference circuit (Net 1) at the input to the MILA site. Note the

initial turn-on tone has been filtered out by the filter [F] shown on the drawing. The turn-off tone (2475 Hz) can still be seen (and faintly heard on the recording), but at a low level. The QT-30/QR-30 transmitter receiver combination has a back-to-back response time of about 30 milliseconds, including (according to equipment specifications) about 16 milliseconds for the reaction time of the relay at the output of the QR-30 receiver which activates the keying relay. The Quindar reaction time appears to be almost an order of magnitude faster than the missing initial syllables as shown on Figure A-3, which is the spectrogram of the same Cap Comm transmission taken at the CSM USB A/G loop record point and shows the clipping after the keying relay Q1. Figure A-4 shows the same transmission taken at the VHF A/G loop record point.

The following sections catalog the presence or absence of the Quindar tones as observed on the MCC, MILA and Bermuda tapes. This was done to verify that all transmissions from MCC did contain tones for the time period analyzed.

MILA

Goss Conference - Every Cap Comm transmission had the closing Quindar tone. In a few instances, it is believed the tail-end of the initial Quindar tone was heard.

VHF A/G Loop - No beginning Quindar tones could be heard. In some transmissions, the end Quindar tone was faintly heard.

USB A/G Loop - Weak Quindar tones were heard at the end of most uplink transmissions and verified on the USB verification receiver recording. No initial Quindar tones were heard.

BERMUDA

Goss Conference

1. Faint Quindar tones heard at the end of all Cap Comm transmissions; none at the beginning.

2. Echo pickup on Goss Conference on the downlink voice cleared at $6^{m}:00^{s}$, reappeared at $10^{m}:52^{s}$, and remained until the end of the tape, $14^{m}:45^{s}$.

APPENDIX A

VHF A/G Loop

1. Uplink contained heavy echoes from $4^m:03^s$ when tape starts until $8^m:40^s$ when tape ends. Quindar tones heard at end of most of the transmissions.

2. Downlink was distorted and echoes for entire period. Distortion heavier at some times to the point where could not understand. This may be a local recording and/or line termination problem.

USB A/G Loop

1. Closing Quindar tone (key off) can be heard.

2. No evidence of first tone (key on).

MCC

A/G-2

1. For the one minute of U/L transmission, a slight initial Quindar tone squeak was evident before each transmission.

2. The closing Quindar could be heard in most cases.

Goss Conference (A/G-1) - All Cap Comm transmissions started and ended with a Quindar tone. The starting Quindar tone often overlapped the first syllable (see Figure A-1).

FIGURE A-1 MCC GOSS CONFERENCE

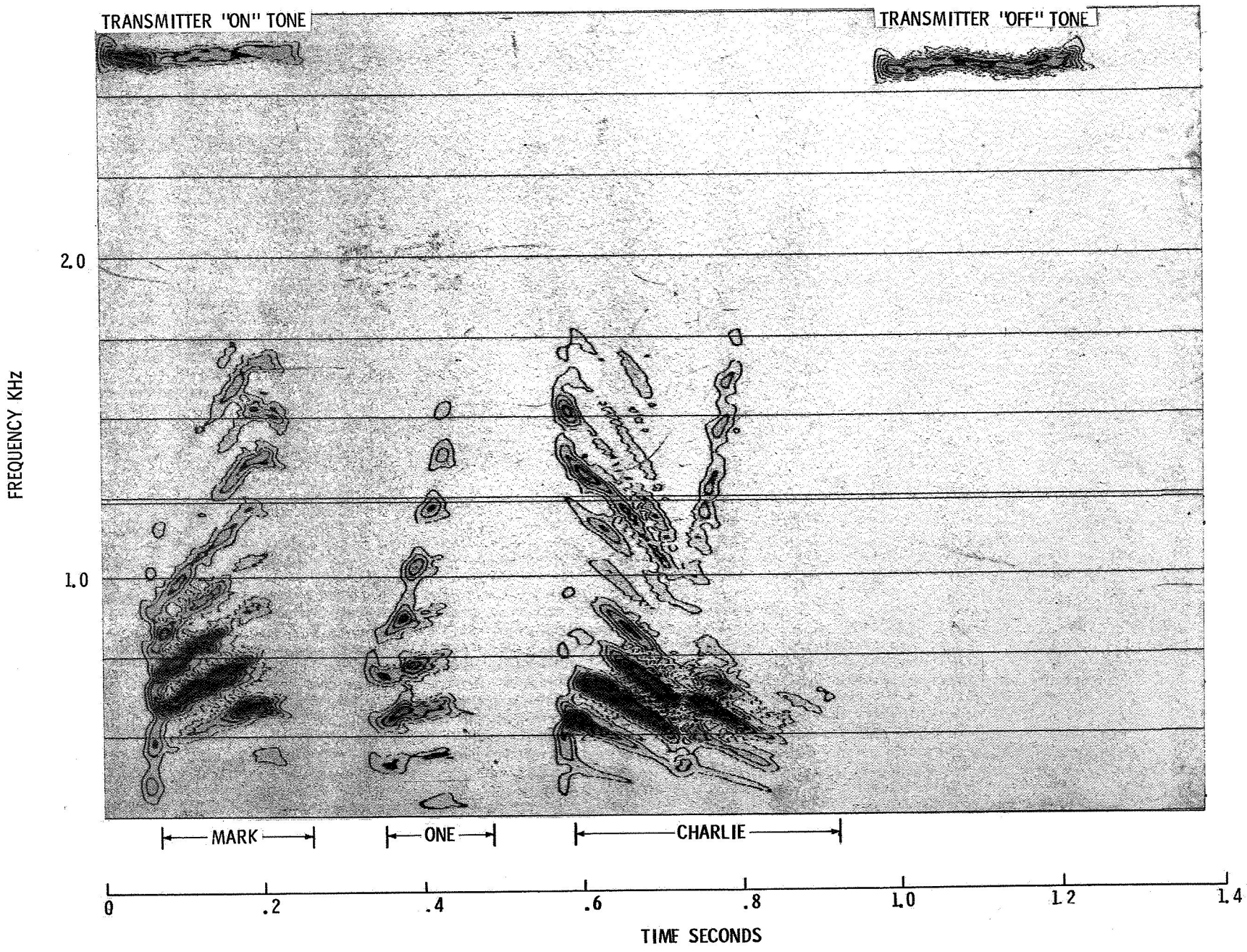


FIGURE A-2 MILA GOSS CONFERENCE

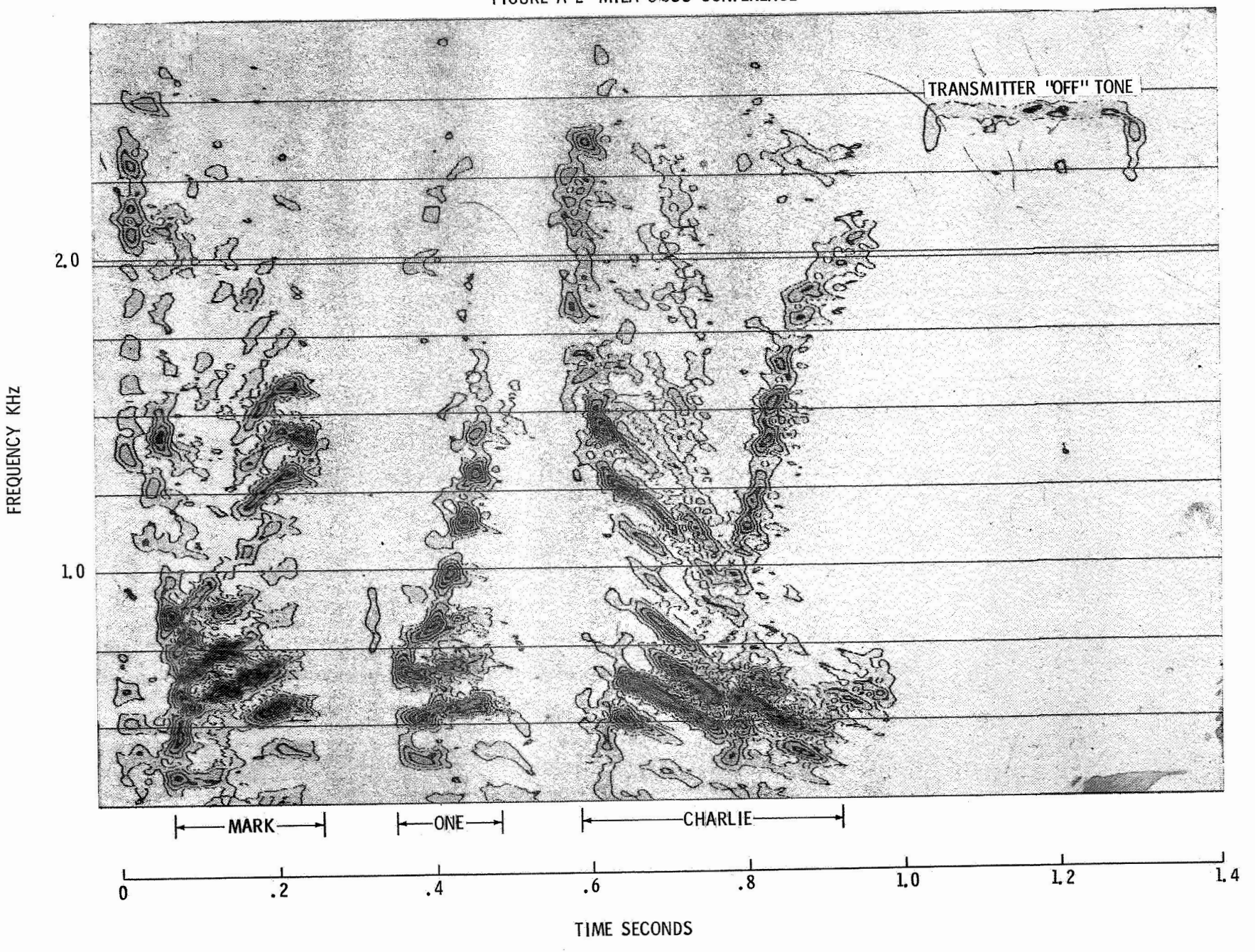


FIGURE A-3 MILA USB A/G LOOP

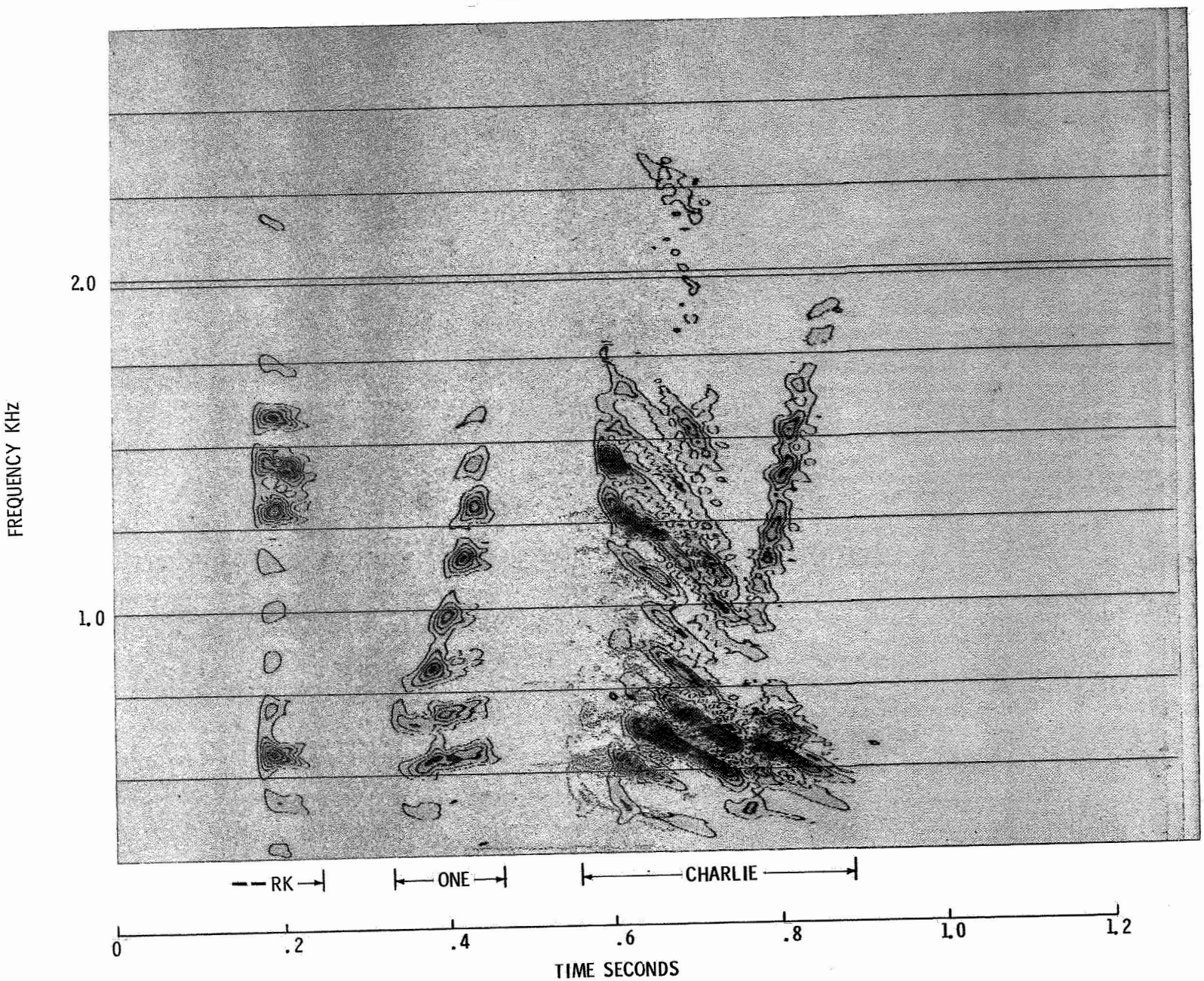
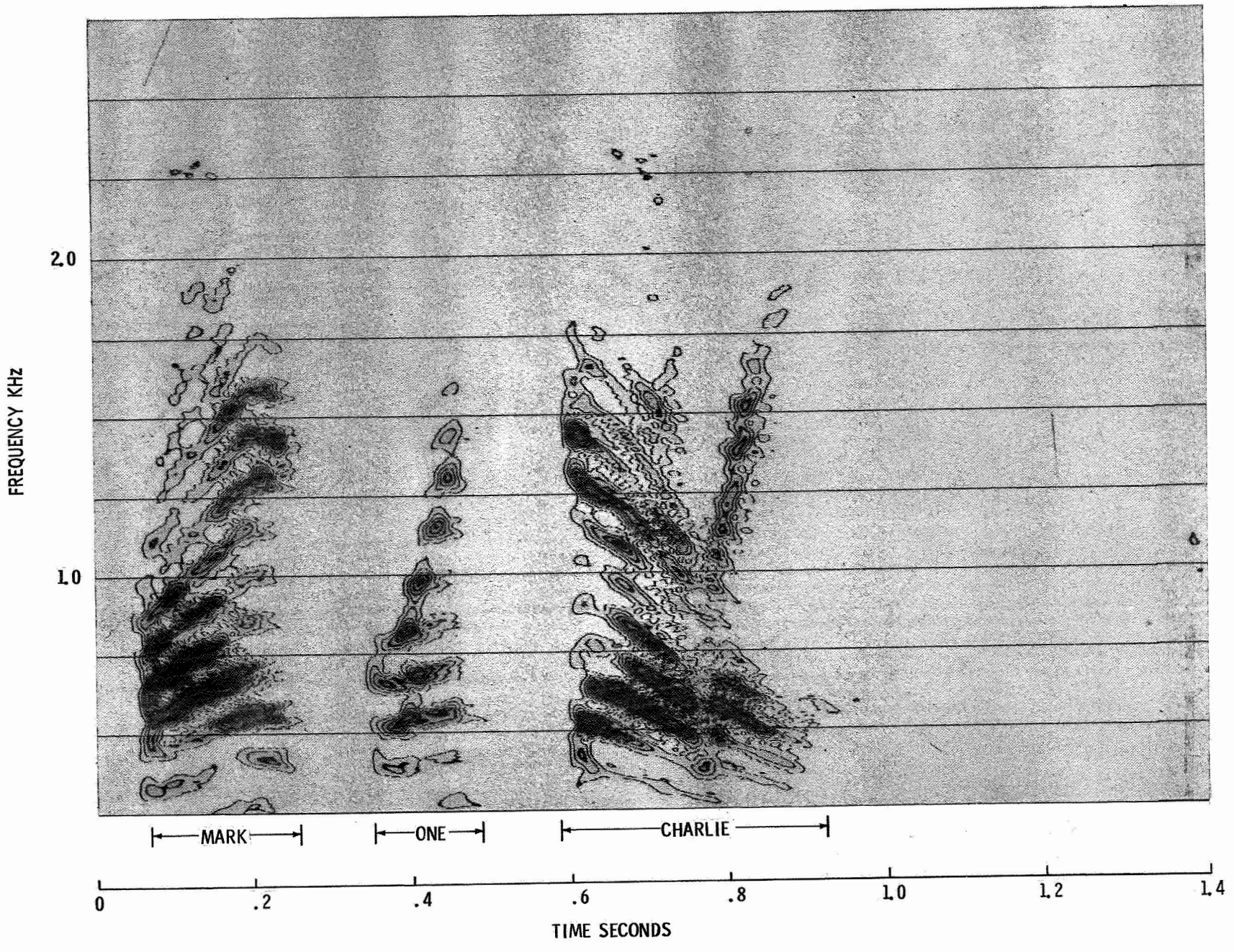
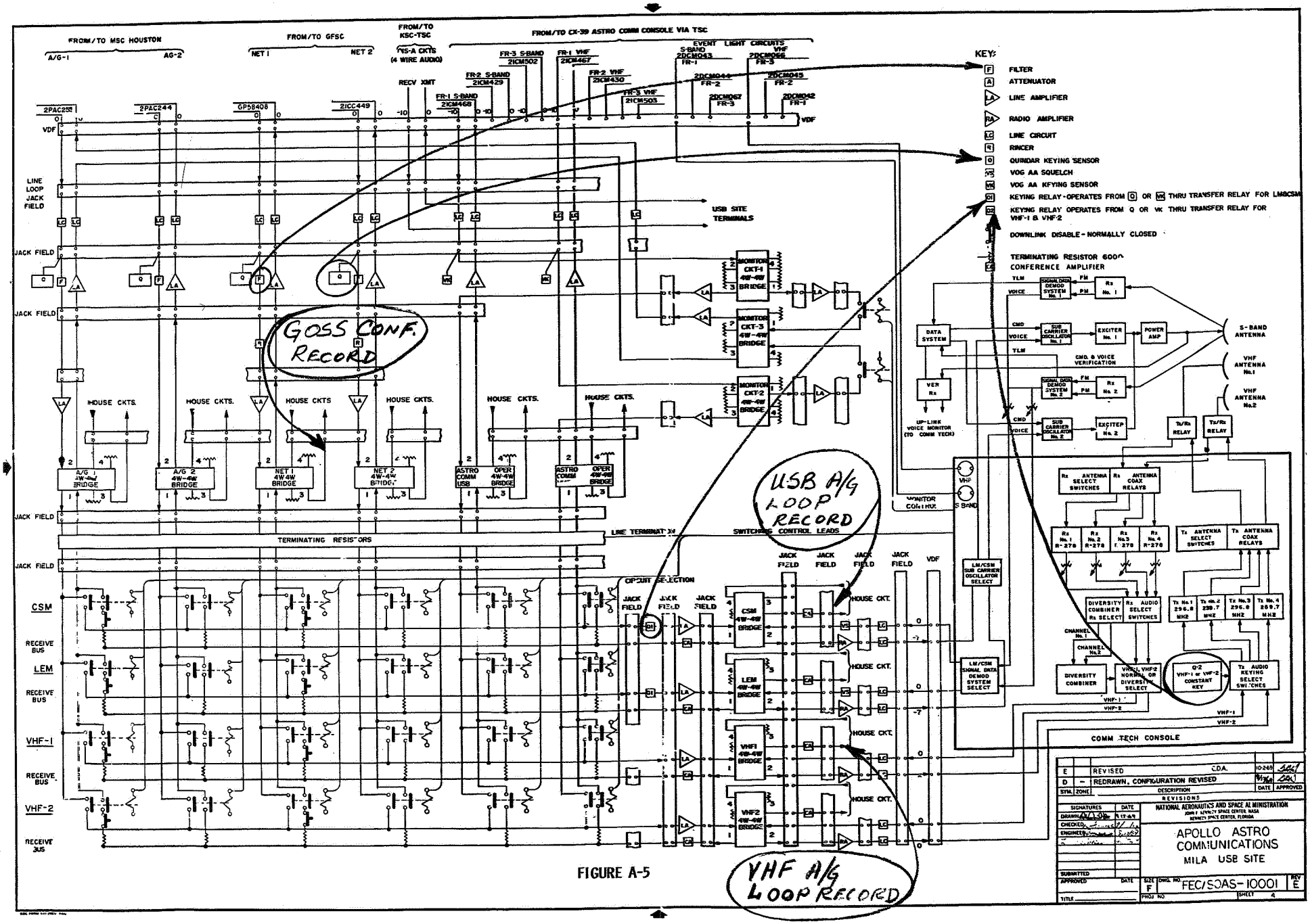


FIGURE A-4 MILA VHF A/G LOOP




FROM/TO MSC HOUSTON
A/G-1
AG-2
FROM/TO GFSC
NET 1
NET 2
FROM/TO KSC-TSC
FROM/TO CX-39 ASTRO COMM CONSOLE VIA TSC
EVENT LIGHT CIRCUITS
KEY:
F FILTER
A ATTENUATOR
LA LINE AMPLIFIER
RA RADIO AMPLIFIER
LC LINE CIRCUIT
R RINCER
Q QUINDAR KEYING SENSOR
VS VOG AA SQUELCH
VK VOG AA KEYING SENSOR
DR KEYING RELAY - OPERATES FROM Q OR VK THRU TRANSFER RELAY FOR LM&CSM
DR KEYING RELAY OPERATES FROM Q OR VK THRU TRANSFER RELAY FOR VHF-1 & VHF-2
DOWNLINK DISABLE - NORMALLY CLOSED
TERMINATING RESISTOR 600Ω
CONFERENCE AMPLIFIER
LINE LOOP JACK FIELD
JACK FIELD
USB SITE TERMINALS
HOUSE CKTS.
TERMINATING RESISTORS
LINE TERMINATION
SWITCHING CONTROL LEADS
CIRCUIT SELECTION
CSM
RECEIVE BUS
LEM
RECEIVE BUS
VHF-1
RECEIVE BUS
VHF-2
RECEIVE BUS
GOSS CONF. RECORD
USB A/G LOOP RECORD
VHF A/G LOOP RECORD
COMM TECH CONSOLE
S-BAND ANTENNA
VHF ANTENNA No.1
VHF ANTENNA No.2
FIGURE A-5
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MILA USB SITE
FEC/SOAS-10001

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